



## PIER Energy-Related Environmental Research

Environmental Impacts of Energy Generation, Distribution and Use

### Dynamic Ecosystem Modeling for California

**Contract #:** 500-02-004

**Contractor:** Conservation International

**Contract Amount:** \$600,000

**Contractor Project Manager:** Lee Hannah

**Commission Contract Manager:** Guido Franco

#### The Issue

Climate change can alter the type, amount, and location of vegetation in California, which can further alter the state's hydrological cycle and climate—potentially impairing its ability to generate hydropower and increasing the amount of greenhouse gases (GHGs) generated by electric power plants.

Energy production is already a major contributor to GHG emissions such as carbon dioxide (CO<sub>2</sub>). In 1999, for example, electricity generation emitted 55.3 million metric tons (MMT) of CO<sub>2</sub>—adding to the more than 200 MMT released that same year by the transportation sector.<sup>1</sup> Because of this significant contribution, it is important that state energy research and development efforts investigate the effects of GHG emissions on state resources.

Most experts agree that increased concentrations of atmospheric GHGs warm the atmosphere and force the climate to change. In the last century alone, the average global surface temperature increased about 1.08°F,<sup>2</sup> in comparison to a rise of only 0.9°F in the 400 years prior to 1900.<sup>3</sup> Much of this change is attributed to substantial increased quantities of atmospheric GHGs. However, changes in the albedo<sup>4</sup> of surface vegetation can also affect climate and hydrology. Changes to surface vegetation, such as altered composition of species or structural characteristics, can influence the amount of energy that is re-radiated to the atmosphere as long-wave radiation, which is the energy that is trapped by GHGs and which contributes to warming.<sup>5</sup> In fact, these albedo changes may be as important as the greenhouse effect at the regional level.<sup>6</sup>

As vegetation patterns and hydrology change, further affecting the climate, energy demand and hydropower availability could be affected. One recent study concluded that electricity demand

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<sup>1</sup> California Energy Commission. 2002. *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999*. Staff Report. 600-02-001F. p. 8.

<sup>2</sup> Intergovernmental Panel on Climate Change. 2001. *Climate Change 2001: The Scientific Basis. Technical Summary*. pg. 26.

<sup>3</sup> Houghton, J. T., L. G. Meira Filho, B. A. Callander, N. Harris, A. Kattenberg, and K. Maskell, editors. 1996. *Climate Change 1995: The Science of Climate Change*. Cambridge University Press, Cambridge.

<sup>4</sup> Albedo refers to the ability of a surface to reflect radiant energy.

<sup>5</sup> Known as *the greenhouse effect*.

<sup>6</sup> Dr. Margaret Torn. 2002. Lawrence Berkeley National Laboratory. Personal communication.

will increase under increased warming,<sup>7</sup> and many studies have predicted a decrease in summer streamflow,<sup>8</sup> which will result in less water to generate hydropower when demand is the highest.

Moreover, albedo changes tied to vegetation shifts could lead to a higher level of GHG emissions in the state. Power plants that serve California's electricity demand already represent about 28% of the state's carbon dioxide (CO<sub>2</sub>) emissions.<sup>9</sup> If less hydropower is available to meet a higher demand, it is likely to be met with electricity from fossil-fuel-powered facilities, which will increase the state's CO<sub>2</sub> emissions.

The PIER program has funded research that used dynamic vegetation models to investigate changes in California's vegetation under different climatic scenarios, with a focus on timber markets and coastal sage scrub. However, these models did not account for significant factors that affect broader ecosystem interactions such as land use, the age and spatial structure of plant and animal populations, dispersal rates and modes of different species, and the potential impacts of invasive species. Without the inclusion of such variables, estimates of changing vegetation patterns are not robust enough to make solid assertions of likely impacts.

The development of accurate dynamic ecosystem models could help researchers better understand the interplay between the type, amount, and location of vegetation in California and the implications for the state in terms of altered hydrological patterns and increased GHGs.

Research and development on this issue was strongly supported by the technical advisory committee that evaluates projects to be funded through PIER's Global Climate Change Grant Program.

## **Project Description**

In this project, PIEREA is funding work by Conservation International to enhance a landscape model called BioMove. This model will advance beyond conventional ecosystem models to project the impacts of climate change on individual species within a region's flora and fauna, by incorporating interactions of plant and animal species with each other and their physical environment.

The BioMove model was developed to assess climate change effects on biodiversity hotspots, areas with high numbers of unique species, and high levels of threat, such as those in California. This project will improve BioMove and use it in conjunction with other models, at coarser and finer scales. This model ensemble approach will be applied to endemic plants and plants of conservation interest in California.

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<sup>7</sup> Mendelsohn, Robert. 2003. Appendix XI: The Impact of Climate Change on Energy Expenditures in California. In *Global Climate Change and California: Potential Implications for Ecosystems, Health, and the Economy*. Draft Final Report. February 10.

<sup>8</sup> Miller, N. L., K. E. Bashford, and E. Strem. 2003. Appendix VIII: Climate Change Sensitivity Study of California Hydrology. In *Global Climate Change and California: Potential Implications for Ecosystems, Health, and the Economy*. Draft Final Report. February 10.

<sup>9</sup> Franco, G., R. Wilkinson, A. Sanstad, M. Wilson, and E. Vine. 2003. *Climate Change Research, Development, and Demonstration Plan*. California Energy Commission, Public Interest Energy Research. P500-03-025S. ES-5.

This project's goals are to: (1) further develop BioMove so that it becomes a fully operational, fully tested, parameterized model for impact prediction in six target ecosystems in California, and (2) test run BioMove in four ecoregions at varying scales. The project will deliver model code, coupled with databases of input parameters, suitable for desktop applications. The end product of the ensemble modeling will be an advanced impact assessment of the effects of climate change on California's vegetation.

To achieve these goals, the project will pursue three major activities:

1. Model development of BioMove, to create a complete hybrid modeling package capable of simulating both species and vegetation responses, and their interaction, in multiple California vegetation (ecosystem) types.
2. Model parameterization for 4 ecoregions (at least 6 vegetation types) in California, including plant-vertebrate interactions for key species.
3. Model tests at multiple scales, including niche modeling of select species statewide and modeling of competition at select locales.

The lead research institutions for this work are the Center for Applied Biodiversity Science (CABS)—the research science arm of Conservation International—and the National Botanical Institute of South Africa. This work is being funded by the PIER Global Climate Change Grant Program (GCC Grant Program), which is one of three research branches of the California Climate Change Research Center (Center). The GCC Grant Program complements the Center by offering competitive solicitations for climate research topics that are part of the PIER Climate Change Research Plan but that are not covered by the other two branches. The Center's two other branches are: (1) the economic analyses branch, which is administered by the University of California at Berkeley, and (2) the climate analysis and modeling branch, which is administered by the Scripps Institution of Oceanography. The GCC Grant Program will ensure that other research groups have an opportunity to submit proposals for selected research topics and enhance the overall robustness of the Center and PIER-funded climate change research in California.

### **PIER Program Objectives and Anticipated Benefits for California**

This project offers numerous benefits and meets the following PIER program objectives:

- **Developing cost-effective approaches to evaluating and resolving the environmental effects of energy production, delivery, and use in California.** The enhanced dynamic ecosystem model will be used with various climate scenarios developed by other PIER research projects to estimate the changes to ecosystems and their services. It will help PIER to estimate (among other things) the impact of climate change on ecosystems, changes in the frequency and severity of forest fires, and the potential impact of changes of vegetation on regional climate. The information gained from such analyses will benefit both the public and private sector by informing decision making about how to maintain hydropower capacity and could help resolve issues such as the long-term viability of terrestrial carbon sequestration projects in California, which could assist companies reporting their emissions to the California Climate Action Registry.

## **Final Report**

PIER-EA staff intend to post the final report on the Energy Commission website in spring 2007 and will list the website link here.

## **Contact**

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